(LO) noise that needs to be compensated for. Notably, there is no closed automatic frequency correction (AFC) loop possible during the GPS measurement as the input SNR is too low. The lack of AFC, and the use of low cost, low power, RF LO components, implies that there will inevitably be a significant finite offset, drift, and some instability associated with the LO down conversion frequency.

The C/A signal from a GPS SV (space vehicle) is a DS-SS (direct sequence spread spectrum) with a chip rate of 1.023 Mcps. It is modulated as binary phase shift keying (BPSK) on a 1.574 GHz carrier. The GPS receiver correlates the received signal with a locally generated DS-SS code signal. In the AGPS scheme, traditional DS-SS correlation is also done. However, detailed information regarding the doppler shift of the SV GPS signal and code offset is available from the host base station (BS) which significantly reduces the search and detection effort. Nevertheless, the mobile GPS receiver is still required to determine the code delay and doppler to a finer resolution than that available from the host BS such that mobile location is possible.

Based on standard assumptions regarding the noise in the GPS signal channel, the optimum receiver would correlate the signal in a coherent fashion over an integration time period that is sufficiently long to provide about 11 dB SNR at the correlator output. This will typically provide an adequate probability of detection with a reasonable false alarm rate. However, in the case of a mobile GPS receiver, due to the instability of the RF LO and the uncertainly of the SV doppler, the coherent integration epoch needs to be limited. Also valid GPS readings are still required even if the user does not hold the receiver steady. Hence, typically the coherent integration time is limited to 10 msec or less. As the available coherent integration epoch is not sufficient to obtain the sensitivity required, non-coherent summations of sequential coherent correlation integration outputs are used. However, non-coherent processing is a very inefficient means of further enhancing the SNR of a signal as it discards certain known statistical aspects of the signal.

Various examples of the use of Viterbi algorithms for phase trajectory determinations are known. For example US Patent No. 6,477,208 to Huff teaches a method and apparatus for processing a received digitally-modulated carrier signal to coherently demodulate a signal utilizing a composite trellis diagram. However, the method of Huff is only applicable to cases of discrete jumps in phase based on specific modulations. When using a continuous, free running oscillator, the phase steps are continuous in time. Huff does not teach a method for approximating these phase steps.

Summary of the Invention

The method and system of the present invention overcome the above by providing a way to demodulate the RF phase trajectory of a DS-SS correlation, using coherent integration for a small time epoch. The receiver in the present invention downshifts an incoming signal using a local oscillator. The receiver then despreads the signal.

CLAIMS

We Claim:

1. A method of improving sensitivity in the demodulation of a received signal by a receiver over an arbitrary measurement time epoch, said method comprising the steps of:
   correlating said received signal with a local replica of pseudo noise code in a coherent fashion over time intervals in said time epoch creating a correlation signal;
   creating a trellis of evenly distributed phase state nodes at each time interval, said creating step comprising:
      defining a plurality of phase states representing the phases evenly quantized over 0 to 360 degrees;
      defining possible state transitions from and to each phase state node;
      creating paths between phase state nodes in one time interval and phase state nodes in another time interval according said possible state transitions;
      assigning a transition probability to each path; and
      creating a likelihood metric for each path based on a measured phase of the received signal and the transition probability for the path, said measured phase of the received signal having a random process approximated utilizing a discrete Markov process; and
   utilizing a Viterbi algorithm on said trellis to perform a maximum likelihood estimation of a phase trajectory with said quantized resolution of phase states over 0 to 360° throughout the measurement time epoch.

2. The method of claim 1, wherein the Markov process is a first order Markov process.

3. The method of claim 1, wherein the possible state transitions and the probability of the paths are assigned to reflect properties of said receiver.

4. The method of claim 3 wherein the step of creating possible state transitions for each node is performed based on a known phase slew rate limitation of said receiver.

5. The method of claim 4, wherein the known phase slew rate limitation is calculated from the instability of a radio frequency local oscillator in said receiver.

6. The method of claim 1, wherein the received signal is a direct sequence spread spectrum signal.

7. The method of claim 1, wherein the received signal is a global positioning system (GPS) coarse/acquisition LI signal generated by a space vehicle (SV).

8. The method of claim 4, wherein the received signal is a global positioning system (GPS) coarse/acquisition LI signal generated by a space vehicle (SV).

9. The method of claim 1 wherein the received signal is a code-division multiple access (CDMA) pilot signal.

10. The method of claim 8, wherein the GPS SV creates a doppler shift in the phase trajectory, and the known phase slew rate limitation is calculated from the uncertainty of the GPS SV doppler shift.

11. The method of claim 8, wherein the known phase slew rate limitation is calculated from both the instability of a radio frequency local oscillator in said receiver and the uncertainty of the GPS SV doppler.

12. The method of claim 1, wherein the likelihood metric is created based on an approximation of a probability distribution function of the phase of said correlation signal.

13. The method of claim 12, wherein the approximation is to model the probability distribution function of the phase as a periodic gaussian pulse on top of a constant function.

14. The method of claim 1 wherein said receiver is a mobile receiver.

15. A receiver for receiving a direct sequence spread spectrum signal, said receiver comprising:

an antenna for receiving the direct sequence spread spectrum signal;

a downconverter for downconverting the received signal, producing a downconverted signal;

an analog to digital converter to convert the downconverted signal to a digital signal;

a despreader for despreading and coherently correlating the digital signal to a known signal, creating a despread signal; and

a processor for applying a Viterbi algorithm to a trellis created for the despread signal, the processor:

breaking the despread signal into time intervals;

creating the trellis of evenly distributed phase state nodes at each time interval by:

defining a plurality of phase states representing the phases evenly quantized over 0 to 360 degrees;

defining possible state transitions from and to each phase state node;

creating paths between phase states node in one time interval and phase state nodes in another time interval according to said possible state transitions;

assigning a transition probability to each path; and

creating a likelihood metric for each path based on a measured phase of said received signal and the transition probability for the path, the measured phase of the despread signal having a random process approximated by a Markov process; and

utilizing the Viterbi algorithm on said trellis to perform a maximum likelihood estimation of a phase trajectory with said quantized resolution of phase states over 0 to 360° throughout the time interval.

16. The receiver of claim 15, wherein the Markov process is a first order Markov process.

17. The receiver of claim 15, wherein the received signal is a global positioning system coarse/acquisition (C/A) LI signal generated by a space vehicle (SV).

18. The receiver of claim 15, wherein the received signal is a CDMA pilot signal.

19. The receiver of claim 15, wherein the receiver is a mobile receiver.

20. The receiver of claim 15, wherein the known signal is a GPS C/A L1 signal.

21. The receiver of claim 20, wherein the possible state transitions and the probability of the paths are assigned to reflect properties of said receiver.

22. The receiver of claim 21, wherein the possible state transitions for each node are based on a known phase slew rate limitation of said receiver.

23. The receiver of claim 22, wherein the known phase slew rate limitation is calculated from the instability of a radio frequency local oscillator in said receiver.

24. The receiver of claim 17, wherein the GPS SV creates a doppler shift in a phase trajectory of said received signal, and the known phase slew rate limitation is calculated from the uncertainty of said GPS SV doppler shift.

25. The receiver of claim 17, wherein the possible state transitions for each node are based on a known phase slew rate limitation of said receiver.

26. The receiver of claim 25, wherein the known phase slew rate limitation is calculated from both the instability of a radio frequency local oscillator in the receiver and the uncertainty of the GPS SV doppler.

27. The receiver of claim 15, wherein the likelihood metric is created based on an approximation of a probability distribution function of the phase of said despread signal.

28. The receiver of claim 27, wherein said approximation is to model the probability distribution function of the phase as a periodic gaussian pulse on top of a constant function.